DARK ENERGY
SURVEY

DECam CCD Quantum Efficiency Measurements

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CCD Quantum Efficiency

DES science requirements place a requirement on the acceptable QE especially in the NIR.

- Absolute QE [g r i z] > [60% 75% 70% 65%]
- Requirement to measure absolute QE for each device

Absolute QE = #e- / #photons

$$QE(\lambda) = (N_{ADU}(\lambda) / G) * (h * c) / (K * P(\lambda) * t * \lambda)$$

Sensitive to G (gain) and K (light ratio at CCD to sphere)

Relative QE removes G and K but gives QE spectrum shape

$$QE(\lambda) / QE(\lambda_o) = N(\lambda) / N(\lambda_o) * (P(\lambda_o) * \lambda_o)/(P(\lambda) * \lambda)$$

Measurement Setup

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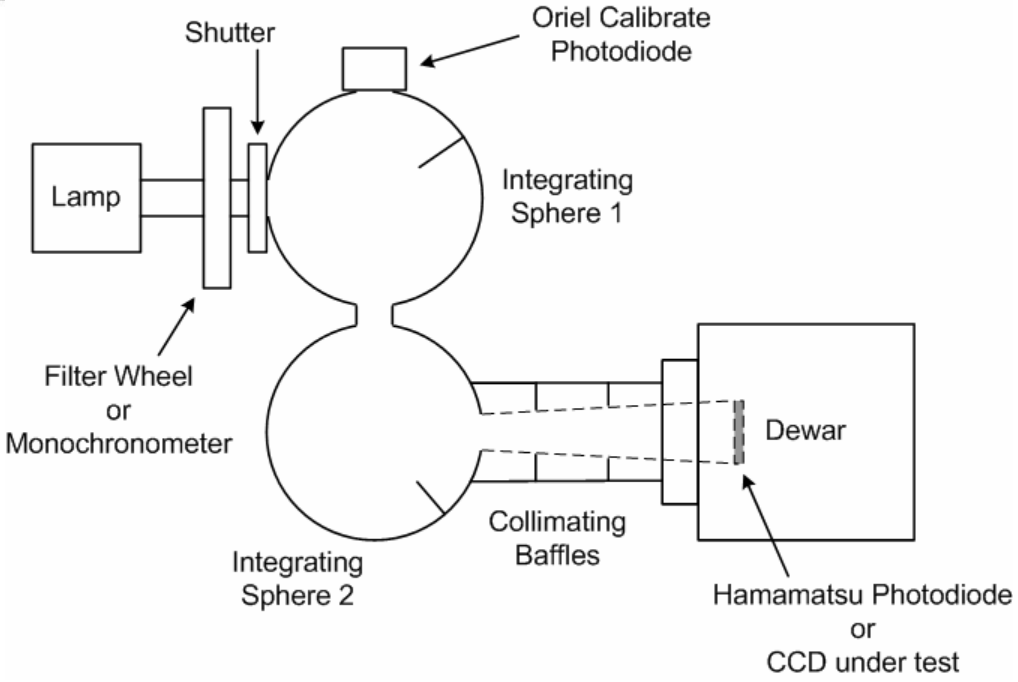

Calibrated photodiode-to-dewar light ratio determined by using calibrated photodiode at CCD location.

P(CCD) = K * P(sphere)

CCD illumination biggest concern:

- Use 2 sphere setup to minimize non-uniform lighting
- Most devices measured with filter wheel at 400, 480, 600, 700, 800 and 1000 nm
  - Use monochronometer on a few devices
- Use collimating baffle to get good flat field (~3%) and minimize stray light

Absolute QE Measurement

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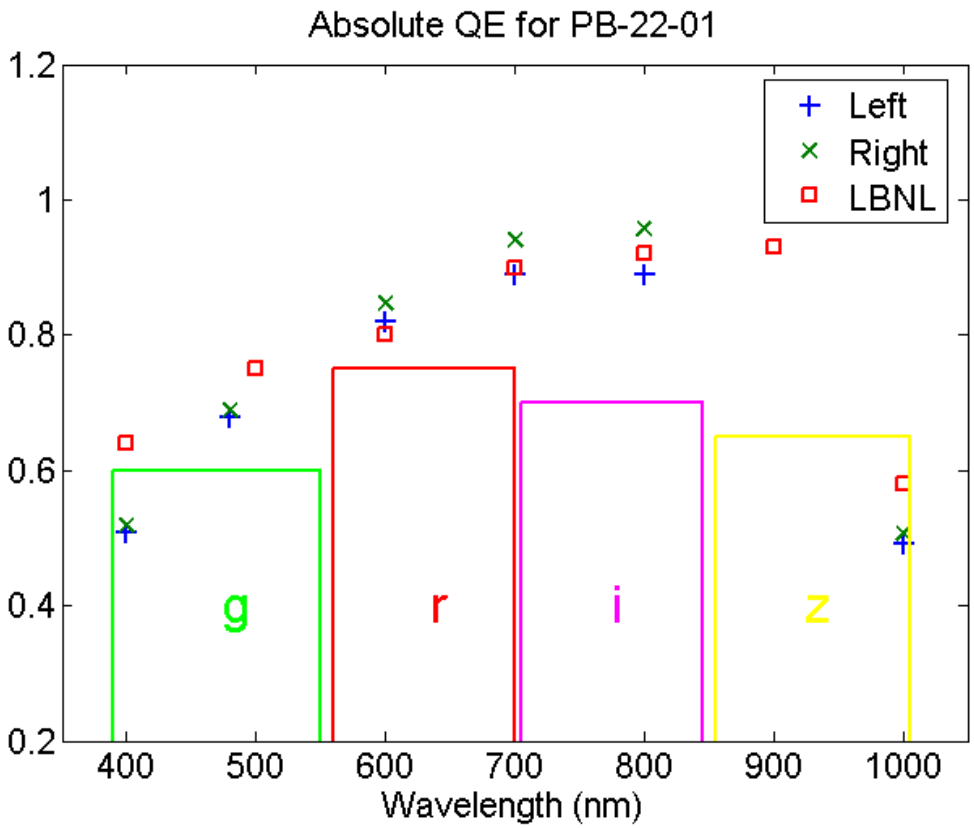
Absolute QE for single device for right and left channels

- Comparison to different device measured at LBNL
- *Reduced blue response may be to back surface issue*
- Biggest uncertainty in gain (~3%) and incident light levels (~10%)



Relative QE for Two Devices

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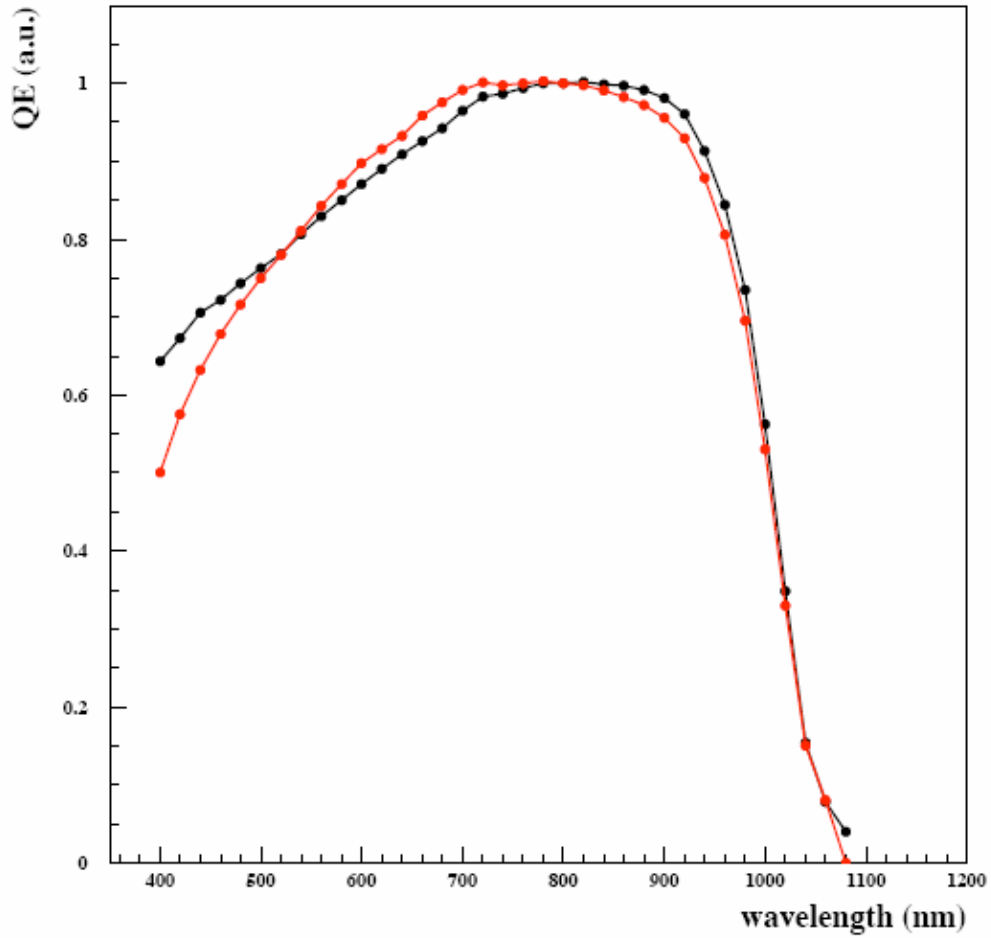

Relative QE (normalized to 800 nm) for two DECam CCS from engineering runs Lot 1A (red) and lot 1B (black)

- *Difference in blue may be due to variation in CCD back surface*

Shows QE device-to-device variation < 5% (except in blue)

QE versus Temperature

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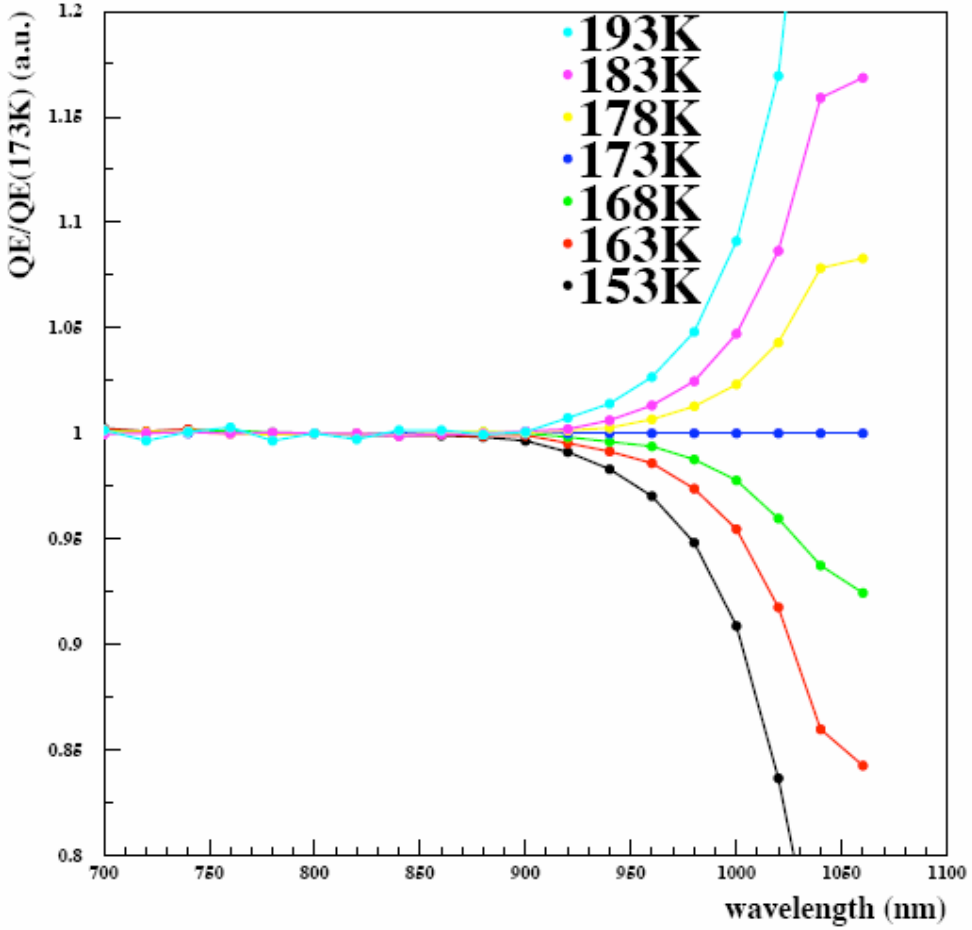

Relative change in QE versus temperature

- ~ 5% QE changes at 1000 nm for a temperature change of 10 degrees

Implies we need temperature stability of 1 degree K at each CCD to meet spec across all wavelengths